

CALIBRATION STANDARD REQUIREMENT
FOR A
LOW FREQUENCY
SIGNAL GENERATOR CALIBRATOR SYSTEM
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PROCUREMENT PACKAGE

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CALIBRATION STANDARD REQUIREMENT FOR A
LOW FREQUENCY SIGNAL GENERATOR CALIBRATOR SYSTEM

1. SCOPE

1.1 Scope. This requirement defines the mechanical, electrical, and electronic characteristics for a Low Frequency Signal Generator Calibrator System. This equipment is intended to be used by Navy personnel in shipboard and shore based laboratories to help calibrate various microwave instruments. For the purposes of this requirement, the Low Frequency Signal Generator Calibrator System shall be referred to as the LFSGCS.

1.2 LFSGCS System. The LFSGCS shall consist of a Signal Generator, Synthesized CW Generator, Sensor Module, Microwave Converter. The LFSGCS shall utilize a 1722A/AP Instrument Controller or equivalent.

2. APPLICABLE DOCUMENTS

2.1 Controlling Specifications. MIL-T-28800, "Military Specification, Test Equipment for use with Electrical and Electronic Equipment, General Specification for," and all documents referenced therein of the issues in effect on the date of the solicitation shall form a part of this requirement.

3. REQUIREMENTS

3.1 General. The LFSGCS shall conform to Type II, Class 5, Style E requirements as specified in MIL-T-28800 for Navy shipboard and shorebased use as modified below. The use of material restricted for Navy use shall be governed by MIL-T-28800.

3.1.1 Design and Construction. The LFSGCS design and construction shall meet the requirements of MIL-T-28800 for Type II equipment.

3.1.2 Power Requirements. The LFSGCS shall operate from a source of 103.5V to 126.5V at 50 and 60 Hz 5% single-phase input power as specified in MIL-T-28800.

3.1.2.1 Fuses or Circuit Breakers. Fuses or circuit breakers shall be provided. If circuit breakers are used, both sides of the power source shall be automatically disconnected from the equipment in the event of excessive current. If fuses are used, only the line side of the input power line as defined by MIL-C-28777, shall be fused. Fuses or circuit breakers shall be readily accessible.

3.1.2.2 Power Connection. The requirements for power source connections shall be in accordance with MIL-T-28800 with a 6-foot (1.8 m) minimum length cord.

3.1.3 Dimensions and Weight. Maximum dimensions shall not exceed 19 inches (48.3 cm) in width, 12 inches (30.5 cm) in height, and 24 inches (61 cm) in depth. The weight shall not exceed 60 pounds (27.6 kg).

3.1.4 Lithium Batteries. Per MIL-T-28800, lithium batteries are prohibited without prior authorization. A request for approval for the use of lithium batteries, including those encapsulated in integrated circuits, shall be submitted to the procuring activity at the time of submission of proposals. Approval shall apply only to the specific model proposed.

3.2 Environmental Requirements. The LFSGCS shall meet the environmental requirements for Type II, Class 5, Style E equipment with the deviations specified below.

3.2.1 Temperature and Humidity. The LFSGCS shall meet the conditions below:

	<u>Temperature (°C)</u>	<u>Relative Humidity (%)</u>
Operating	10 to 30	95
	30 to 40	75
Non-operating	-40 to 70	Not Controlled

3.2.2 Electromagnetic Compatibility. The electromagnetic compatibility requirements of MIL-T-28800 are limited to the following areas: CE01, CE03, CS01, CS02, CS06, RE01, RE02 (14 kHz to 1 GHz), and RS03.

3.3 Reliability. Type II reliability requirements are as specified in MIL-T-28800.

3.3.1 Calibration Interval. The LFSGCS shall have a 85% or greater probability of remaining within tolerances on all requirements at the end of a 26 month period.

3.4 Maintainability. The LFSGCS shall meet the Type II maintainability requirements as specified in MIL-T-28800 except the lowest discrete component shall be defined as a replaceable assembly. Certification time shall not exceed 60 minutes.

3.5 Performance Requirements. The LFSGCS shall provide the following capability as specified below. Unless otherwise indicated, all requirements shall be met following a 30 minute warm-up period.

3.5.1 Signal Generator. The LFSGCS shall provide a Signal Generator which shall meet the following requirements.

3.5.1.1 Frequency. The LFSGCS's Signal Generator shall be capable of measuring the frequency of the applied RF signal.

3.5.1.1.1 Frequency Range. The LFSGC's Signal Generator shall have a frequency range of 20 Hz to 250 kHz at the low frequency input connector; 150 kHz to 1300 MHz at the RF input connector.

3.5.1.1.2 Frequency Resolution. The LFSGC's Signal Generator frequency resolution shall be six (6) digits from 20 Hz to 250 kHz; 1 Hz from 150 kHz to 1300 MHz.

3.5.1.1.3 Frequency Accuracy. The LFSGC's Signal Generator frequency accuracy shall be as follows:

<u>Accuracy</u>	<u>Frequency</u>
± 3 counts of LSD* \pm Reference Accuracy	<100 MHz
± 3 counts of LSD* \pm Reference Accuracy or 30 Hz, whichever is larger	>100 MHz

* LSD: Least-Significant Digit.

3.5.1.1.4 Frequency Sensitivity. The LFSGC's Signal Generator frequency sensitivity shall be as follows:

<u>Sensitivity</u>	<u>Frequency Range</u>
100 mV	20 Hz - 250 kHz
-25 dBm	150 kHz - 650 MHz
-20 dBm	650 MHz - 1300 MHz

3.5.1.1.5 Internal Reference Oscillator. The LFSGC's Signal Generator shall have an internal reference oscillator.

3.5.1.1.5.1 Internal Reference Aging Rate. The LFSGC's Signal Generator shall have an internal reference aging rate of 1×10^{-9} /day or less.

3.5.1.1.5.2 Internal Reference Temperature Effects. The LFSGC's Signal Generator shall have an internal reference temperature effects of Less than $3 \times 10^{-10}/^{\circ}\text{C}$.

3.5.1.1.5.3 Line Voltage Effects. The LFSGC's Signal Generator internal reference oscillator shall have line voltage effects of 9×10^{-10} or less for line voltage changes of +5% to -10%.

3.5.1.1.5.4 Short Term Stability. The LFSGC's Signal Generator internal reference oscillator shall have short term stability of 2×10^{-9} or less for one second average.

3.5.1.2 Power (High Level). The LFSGC's Signal Generator shall be capable of measuring the applied power* with the following requirements:

*Applied power is defined as the power incident upon a non-reflecting termination in a system whose characteristic impedance is 50 ohms.

3.5.1.2.1 High Power Level Range. The LFSGC's Signal Generator with power sensor module connected shall perform RF power measurements from -20 dBm to +30 dBm at frequencies from 100 kHz to 1300 Mhz.

3.5.1.2.2 High Power Accuracy. The high power accuracy shall not exceed ± 0.2 dB.

3.5.1.2.3 High Power Resolution. The high power resolution shall be 0.01 dB or better.

3.5.1.3 Power (Low level). The LFSGCS's Signal Generator shall be capable of measuring the applied power using, if necessary, a reference power measurement by using a high-level power detector specified in paragraph 3.5.2.

3.5.1.3.1 Low Power Frequency Range. The LFSGCS's Signal Generator low power frequency range shall be from 2.5 MHz to 1300 MHz.

3.5.1.3.2 Low Power Range. The LFSGCS's Signal Generator low power range shall be from 0 to -110 dBm.

3.5.1.3.3 Low Power Accuracy. The LFSGCS's Signal Generator low power accuracy shall not exceed ± 0.35 dB.

3.5.1.3.4 Low Power Resolution. The power resolution shall be 0.01 dB or better.

3.5.1.4 Attenuation (Power Ratio). The LFSGCS's Signal Generator shall be capable of calculating and displaying the attenuation value resulting from two power measurements.

3.5.1.4.1 Attenuation Frequency Range. The LFSGCS's Signal Generator frequency range of the attenuation measurements shall be from 2.5 MHz to 1300 MHz.

3.5.1.4.2 Attenuation Dynamic Range. The LFSGCS's Signal Generator dynamic range shall be at least 110 dB.

3.5.1.4.3 Attenuation Accuracy. The LFSGCS's Signal Generator shall have an attenuation accuracy of ± 0.03 dB/10 dB, with a maximum cumulative error of ± 0.3 dB, excluding mismatch errors and connector repeatability.

3.5.1.4.4 Attenuation Resolution. The LFSGCS's Signal Generator resolution of the attenuation measurements shall be 0.001 dB or better.

3.5.1.5 Amplitude Modulation (AM). The LFSGCS's Signal Generator shall be capable of measuring amplitude modulation characteristics.

3.5.1.5.1 The Carrier Frequency Characteristics. The carrier frequency characteristics shall have the following requirements.

3.5.1.5.1.1 Power Input. The LFSGCS's Signal Generator power input of carrier frequency shall be from +10 dBm to -20 dBm.

3.5.1.5.1.2 Carrier Frequency. The LFSGCS's Signal Generator carrier frequency shall be from 150 kHz to 1300 Mhz.

3.5.1.5.2 Amplitude Modulation Frequency. The LFSGCS's Signal Generator shall be capable of measuring the frequency of the amplitude modulation.

3.5.1.5.2.1 AM Frequency Range. The LFSGCS's Signal Generator AM frequency range shall be from 20 Hz to 100 kHz.

3.5.1.5.2.2 AM Frequency Accuracy. The AM frequency accuracy for AM peak greater than or equal to 10% shall be as follows:

<u>Accuracy</u>	<u>Demodulated Frequency</u>
(3 digits (Internal Reference Accuracy	(1 kHz
(0.02 Hz (Internal Reference Accuracy	(1 kHz

3.5.1.5.2.3 Amplitude Modulating Signal Output Sensitivity. The output sensitivity of the amplitude modulating signal shall be as follows:

<u>Maximum Demodulated Output Sensitivity</u>	<u>Depths</u>
0.01V/percent	AM Peak (40%
0.1V/percent	AM Peak (40%

3.5.1.5.2.4 AM Frequency Resolution. The LFSGCS's Signal Generator resolution of AM frequency shall be six (6) digits or better.

3.5.1.5.3 Percent Modulation. The LFSGCS's Signal Generator shall be capable of measuring the percentage of the amplitude modulation (percent AM), as well as measuring the positive peak percent AM and the negative peak percent AM.

3.5.1.5.3.1 AM Depths. The LFSGCS's Signal Generator shall have the capability to measure AM depth at least from 5% to 99%.

3.5.1.5.3.2 AM Accuracy. The LFSGCS's Signal Generator shall have maximum AM measurements accuracy as follows:

<u>Freq. Range</u>	<u>Rate</u>	<u>Uncertainty</u>
150 kHz - 10 MHz	20 Hz - 10 kHz	((3% iv + 1 digit)
150 kHz - 10 MHz	50 Hz - 10 kHz	((2% iv + 1 digit)
10 MHz - 1300 MHz	20 Hz - 100 kHz	((3% iv + 1 digit)
10 MHz - 1300 MHz	50 Hz - 50 kHz	((1% iv + 1 digit)

3.5.1.5.3.3 AM Resolution. The LFSGCS's Signal Generator shall have AM resolution of 0.1% or better.

3.5.1.5.3.4 AM Distortion Measurement of RF Carrier. The LFSGCS's Signal shall have the AM distortion measurement of RF carrier as follows:

Modulation Frequency: 400 Hz \pm 5%, 1 kHz \pm 5%.
 Display Range: 0.01% to 100%.
 Minimum Input AM Level: 1.5% peak AM.
 Uncertainty: \pm 1.0 dB.

3.5.1.5.3.5 AM Distortion Measurement of External Audio Source. The LFSGCS's Signal Generator shall have the AM distortion measurement of external audio source as follows:

Modulation Frequencies: 400 Hz \pm 5%, 1 kHz \pm 5%.
 Display Range: 0.01% to 100%.
 Input Voltage Range: 100 mV to 3V.
 Uncertainty: \pm 1.0 dB.

3.5.1.5.3.6 AM Demodulated Output Distortion. The LFSGCS's Signal Generator shall have the AM demodulated output distortion as follows:

<0.3% THD for \leq 50% depth.
 <0.6% THD for \leq 95% depth.

3.5.1.6 Frequency Modulation (FM). The LFSGCS's Signal Generator shall be capable of measuring the frequency modulation characteristics.

3.5.1.6.1 Carrier Frequency Characteristics. The carrier frequency characteristics shall meet the following requirements.

3.5.1.6.1.1 Carrier Frequency Power Input. The power input of carrier frequency shall be from +10 dBm to -20 dBm.

3.5.1.6.1.2 Carrier Frequency. The carrier frequency shall be from 250 kHz to 1300 MHz.

3.5.1.6.2 Frequency of Modulation Frequency. The LFSGCS's Signal Generator shall be capable of measuring the frequency of modulation.

3.5.1.6.2.1 FM Frequency Range. The LFSGCS's Signal Generator FM frequency range shall be from 20 Hz to 200 kHz.

3.5.1.6.2.2 FM Frequency Accuracy. The accuracy of the FM frequency for FM peak greater than or equal to 1.0 kHz shall be as follows:

<u>Accuracy</u>	<u>Demodulated Frequency</u>
(3 digits (Internal Reference Accuracy	(1 kHz
(0.02 Hz (Internal Reference Accuracy	(1 kHz

3.5.1.6.2.3 Frequency Modulating Signal Output Sensitivity. The output sensitivity of the frequency modulating signal shall not exceed 0.01 mV/Hz.

3.5.1.6.2.4 FM Frequency Resolution. The LFSGCS's Signal Generator shall have the FM frequency resolution of 10 Hz or better.

3.5.1.6.3 FM Deviation. The LFSGCS's Signal Generator shall be capable of measuring the deviation of the frequency modulated signal.

3.5.1.6.3.1 FM Deviation Range. The FM deviation range shall be 400 kHz peak maximum for modulation frequency from 20 Hz to 200 kHz.

3.5.1.6.3.2 FM Accuracy. The LFSGCS's Signal Generator shall have FM measurements accuracy as follows:

<u>FM Accuracy</u>	<u>Deviation</u>	<u>Freq. Range</u>
((2% of reading + 1 digit)	(40 kHz peak	250 kHz - 10 MHz
((1% of reading + 1 digit)	(400 kHz peak	10 MHz - 1300 MHz
((5% of reading + 1 digit)	(400 kHz peak	10 MHz - 1300 MHz

3.5.1.6.3.3 FM Deviation Resolution. The resolution of FM deviation shall be four (4) digits or 10 Hz, whichever is greater.

3.5.1.6.3.4 FM Display. The LFSGCS's Signal Generator shall be capable of displaying FM deviation in positive peak, negative peak, peak-to-peak, and average.

3.5.1.6.3.5 FM Distortion Measurement on RF Carrier. The LFSGCS's Signal Generator shall have the FM distortion measurement on RF carrier as follows:

Modulation Frequency: 400 Hz \pm 5%, 1 kHz \pm 5%.
 Display Range: 0.01% to 100%.
 Minimum Input FM Deviation: 150 Hz peak FM.
 Uncertainty: \pm 1.0 dB.

3.5.1.6.3.6 FM Distortion Measurement of External Audio Source.

The LFSGCS's Signal Generator shall have the FM distortion measurement of external audio source as follows:

Modulation Frequency: 400 Hz \pm 5%, 1 kHz \pm 5%.

Display Range: 0.01% to 100%.

Input Voltage Range: 100 mV to 3 V.

Uncertainty: \pm 1.0 dB.

3.5.1.6.3.7 FM Demodulated Output Distortion.

The LFSGCS's Signal Generator shall have the FM demodulated output distortion as follows:

<u>THD</u>	<u>Freq. Range</u>	<u>Rates</u>	<u>Deviation</u>
(0.1%	400 kHz - 10 MHz	20 Hz - 10 kHz	(10 kHz
(0.1%	10 MHz - 1300 MHz	20 Hz - 100kHz	(100 kHz

3.5.1.7 Phase Modulation (PM). The LFSGCS's Signal Generator shall be capable of measuring PM characteristics.

3.5.1.7.1 Carrier Frequency Characteristics.

3.5.1.7.1.1 Carrier Frequency Power Input. The LFSGCS's Signal Generator Power input of carrier frequency shall be from +10 dBm to -20 dBm.

3.5.1.7.1.2 Carrier Frequency. The LFSGCS carrier frequency shall be from 150 kHz to 1300 Mhz.

3.5.1.7.2 Phase Modulation Frequency. The LFSGCS's Signal Generator shall be capable of measuring the deviation of the phase modulated signal.

3.5.1.7.2.1 Phase Modulation Frequency Range. The LFSGCS's Signal Generator PM frequency range shall be from 200 Hz to 20 kHz.

3.5.1.7.2.2 PM Frequency Accuracy. The PM frequency accuracy shall be as follows:

<u>PM Frequency Accuracy</u>	<u>Frequency</u>
((4% of reading + 1 digit)	150 kHz to 10 MHz
((3% of reading + 1 digit)	10 MHz to 1300 MHz

For rms detector add \pm 3% of reading.

3.5.1.7.2.3 PM Output Sensitivity. The output sensitivity of the modulation rate shall be as follows:

<u>Deviation (radians)</u>	<u>Modulation Rates</u>	<u>Modulation Sensitivity</u>
0.1 to 0.4	100 Hz to 1 kHz	1.0V/Radian
0.4 to 4.0	100 Hz to 1 kHz	1.0V/Radian
4.0 to 40	100 Hz to 1 kHz	0.1V/Radian
40 to 400	100 Hz to 1 kHz	0.01V/Radian

3.5.1.7.2.4 PM Frequency Resolution. The LFSGCS's Signal Generator resolution of the modulation rate shall be four (4) digits or 0.1 radians whichever is greater.

3.5.1.7.2.5 PM Demodulated Output Distortion. The LFSGCS's Signal Generator output distortion of phase modulation shall be less than 0.1% THD.

3.5.1.8 High Power Impedance. Nominal 50 ohms.

3.5.1.9 Voltage standing Wave Ratio (VSWR). The VSWR of LFSGCS's Signal Generator shall not exceed 1.15.

3.5.1.10 Power Reference. A built-in power reference shall be provided for calibration.

3.5.2 The Synthesized CW Generator. The LFSGCS shall provide a Synthesized CW Generator which shall meet the following requirements.

3.5.2.1 Frequency Range. The Synthesized CW Generator shall provide a frequency range of 1.0 to 20 GHz.

3.5.2.2 Frequency Resolution. The Synthesized CW Generator shall provide a frequency resolution of 1 kHz.

3.5.2.3 Accuracy. The Synthesized CW Generator shall have the accuracy of -4 dBm at the following frequency range:

10 MHz to 50 MHz, (1.3 dB
50 MHz to 20 GHz, (1.0 dB

3.5.2.4 Flatness. The Synthesized CW Generator shall have the flatness of (0.5 dB.

3.5.2.5 Spectra Purity. The synthesized CW Generator shall provide the spectra purity for the harmonic frequency at less than -50 dB_C (at level (+10 dB_m), and for non-harmonic spurious frequency which is bigger than 3 kHz the spectra purity is -60 dB_C.

3.5.2.6 Phase Noise. The Synthesized CW Generator shall provide the phase noise for the frequency range 500 MHz, 2 GHz, 18 GHz at -103 dB_C/Hz, -91 dB_C/Hz, and -73dB_C/Hz respectively.

3.5.3 Microwave Converter. The LFSGCS shall provide a Microwave Converter which shall meet the following requirements.

3.5.3.1 Frequency Range. The Microwave Converter shall provide the frequency range from 10 MHz to 18 GHz.

3.5.3.2 RF Input. The Microwave Converter's RF input shall be less than 2.0

3.5.3.3 SWR. The Microwave Converter's SWR shall be less than 2.0.

3.5.4 Sensor Module. The LFSGCS shall provide the Sensor Module which shall meet the following requirements.

3.5.4.1 Frequency Range. The Sensor Module shall provide the frequency range from 10 MHz to 18 GHz.

3.5.4.2 RF Power. the Sensor Module shall provide the following RF power.

<u>Ratio</u>		<u>Frequency</u>
(1.10	for	10 Mhz to 2 GHz
(1.20	for	2 GHz to 12.4 GHz
(1.25	for	12.4 GHz to 18 GHz

3.5.4.3 Tuned RF Level. The Sensor Module shall provide the following tuned RF level.

<u>Ratio</u>		<u>Frequency</u>
(1.25	for	10 Mhz to 12.4 Ghz; 0 to -90 dB _m
(2.00	for	10 Mhz to 12.4 GHZ; -90 to -100 dB _m
(1.30	for	12.4 Ghz to 18 Ghz; 0 to -80 dB _m
(2.00	for	12.4 Ghz to 18 Ghz; -80 to -90 dB _m

3.6 Operating Requirements. The LFSGCS's Signal Generator shall provide the following operating capabilities.

3.6.1 Front Panel Control Requirements. All modes and functions shall be operable using front panel controls. The locations and labeling of indicators, controls, and switches shall provide for maximum clarity and easily understood operation without reference to tables, charts, or flow diagrams.

3.6.2 Programmability. All modes and functions shall be fully remotely programmable via the IEEE-488.1 instrumentation bus. When operating the LFSGCS via remote programming, all front panel controls shall be disabled, except for the on / off switch and the Remote / Local switch.

3.6.3 Error Correction. During calibration, the LFSGCS shall provide the capability to correct for all measurement deviations from nominal conditions. This correction capability shall be operational from the front panel control, manual adjustment to printed circuit board, or over the IEEE-488 bus. The LFSGCS shall be capable of changing any calibration factor or other correction data stored in memory of the LFSGCS without removal of any memory circuits or devices.

3.6.4 Local / Remote. The LFSGCS shall have a local and remote operation mode. It shall be either manually or remotely programmable selectable according to paragraph 3.6.2. Manual selection shall be provided by a front panel switch. A means of indicating the operational mode shall be provided. When changing modes, all parameter values shall remain unchanged.

3.6.5 IEEE Interface. The LFSGCS shall have an IEEE-488.1 interface connector with the following capabilities:

- a. SH1 - Source handshake, complete capability.
- b. AH1 - Acceptor handshake, complete capability.
- c. T6 or T5 - Talker function, complete capability.
- d. L4 or L3 - Listener function, complete capability,
including Listen Only mode.
- e. SR1 - Service request, complete capability.
- f. RL1 - Remote local, complete capability.
- g. DC1 - Device clear, complete capability.
- h. E2 or E1 - Driver electronic, open circuit driver.
- i. DT1 - Device trigger, complete capability.

3.6.6 Compatibility. The LFSGCS shall be tested for compatibility with the IEEE-488 bus and the John Fluke Model 1722A/AP instrument controller. The LFSGCS shall be tested for correct operation when controlled using existing United States Navy software programs originally written for use with the Hewlett Packard Model 8902A Option E02 Signal Generator Calibrator.

3.7 Manual. At least two copies of an operation and maintenance manual shall be provided. The manual shall meet the requirements of MIL-M-7298.

3.7.1 Calibration Procedure. The manual shall provide a LFSGCS calibration procedure in accordance with MIL-M-38793.